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(71) Applicant: **Oleo International Limited**
Exhall, Coventry CV7 9ND (GB)

(72) Inventor: **Mombour, Klaus**
47447 Moers (DE)

(74) Representative: **Powell, Timothy John**
Eric Potter Clarkson,
Park View House,
58 The Ropewalk
Nottingham NG1 5DD (GB)

(54) A two stage buffer

(57) A two stage buffer (10) primarily intended for use on railway vehicles includes a primary element in the form of a buffer capsule (12) and a secondary element in the form of a deformable apparatus (11), the primary and secondary elements (12,11) being force-transmittingly connected in series.

The deformable element (11) includes a plastically deformable hollow tube (14) having an internal taper; and a deforming member (15) of generally complementary cross section to the interior of the deformable tube (14).

The deforming member (15) is inserted into the deformable tube (14) such that impact forces experienced by the deformable member are transmitted to the deformable tube (14) whereby the secondary element absorbs impact forces by plastic deformation of the tube (14).

A slit ring (16) interconnects the deforming member (15) and the taper (13) of the tube, the contact pressure between the deformable member (15), the slit ring (16) and the tube (14) being adjustable in order to set a predetermined start force for working of the deformable, secondary element (11).

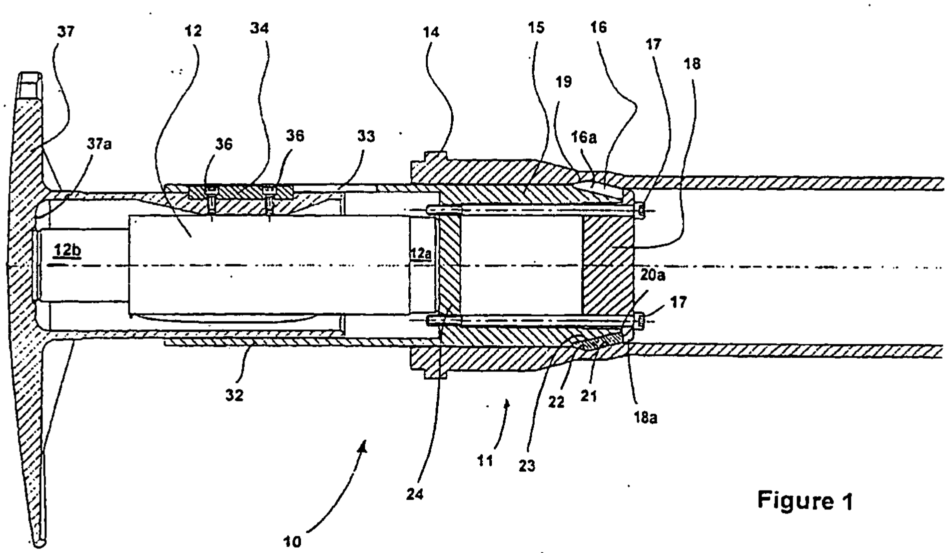

Figure 1

EP 1 247 716 A1

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Description

[0001] This invention relates to a two stage buffer suitable for use on heavy vehicles such as railway locomotives, trams, "light rail" cars, ore trains and some earth moving machines. The primary application of two stage buffers is in impact protection for vehicles that travel on permanent way, especially conventional railways.

[0002] It has for long been known to provide buffers having static and dynamic force absorption characteristics, for the purpose of minimising impact damage from low speed impacts involving railway vehicles.

[0003] Two known kinds of such buffers are single stage hydraulic buffers; and single stage ring spring buffers.

[0004] It is also known to provide polymeric and rubber single stage buffers.

[0005] The various kinds of single stage buffer mentioned have differing force absorption characteristics. A common feature of the buffers, however, is that they are only effective to absorb impacts of heavy vehicles at shunting speeds that typically are less then 15 km/h.

[0006] However, many rail impacts occur outside stations and shunting yards, especially when trains and locomotives cross switches. At such locations the impact speeds between two railway vehicles can reach 40km/h, ie more than can be buffered using hydraulic or ring spring buffers alone.

[0007] Consequently there have been numerous proposals to provide two stage buffers including secondary energy absorbing elements in series with primary absorbing elements in the form of known hydraulic or ring spring buffers.

[0008] In specifying such secondary elements, it is important to assure adequate performance in respect of:

(i) side impacts (that are defined as oblique impacts at angles to the longitudinal axis of a buffer assembly). Side impacts are common at railway switches; and

(ii) the anti-climb characteristics of the two stage buffer in combination with anti-climb apparatus secured in the region of the railway vehicle headstock.

[0009] In the latter connection it is generally believed that railway passenger carriages with anti-climb apparatuses cause fewer injuries and deaths in the event of a crash. It is therefore important that any buffer design does not reduce the effectiveness of anti-climb apparatuses.

[0010] The following secondary elements have been proposed for use in two stage buffers:

1. The wear buffer beam.

This is a beam of deformable material secured adjacent the headstock of a railway carriage, wagon or locomotive. The wear buffer beam absorbs impact energy by bending. Its energy absorbing capacity is limited and consequently its weight and cost are high compared to its effectiveness.

2. A collapsing tube or box

This is essentially a crushable element that operates in series with a conventional buffering element.

The collapsing force in an impact situation is inconsistent. The internal stresses in the collapsing structure change rapidly from compression to buckling. This causes high peak forces and decelerations.

It is also inherent that virtually no components of a collapsible structure are reusable after an impact.

3. High speed deformation / high speed machining elements.

Patent Application No. FR-A-2 789 358 discloses a two stage buffer in which the secondary buffing element operates by high speed broaching of a hollow tube by a machining tool.

In such an arrangement the start force of the secondary element is unknown. Therefore it is necessary to add a further, shear component whose shear force is known.

Nonetheless in the arrangement of FR-A-2 789 358 the start force is difficult to control. The crushing force is also difficult to control; and the device is susceptible to failure through fatigue.

[0011] According to a first aspect of the invention there is provided a two stage buffer as defined in Claim 1.

[0012] The use of a pair of mutually engaged, tapered elements to cause plastic deformation of one of the elements provides a high capacity secondary element in the two stage buffer.

[0013] The arrangement is particularly good at absorbing side impacts, that may be defined as oblique impacts acting at an angle of up to 8° from the longitudinal axis of the buffer (although of course the buffer of the invention absorbs side impacts at other angles).

[0014] The two stage buffer of the invention may conveniently be arranged to be virtually any length, simply by choosing the dimensions of the components employed. It is as a result comparatively easy to devise a two stage buffer that in operation does not interfere with operation of anti-climb equipment fitted to a railway vehicle.

[0015] Also through choice of the dimensions of the components the characteristics of the buffer may be readily

varied. For example, the choice of the diameter of the hollow tube and the deforming member therein may give rise to variations in the characteristics of the buffer.

[0016] Yet a further advantage of the buffer of the invention is that all components thereof, with the exception of the plastically deformable hollow tube, may be re-used following impact.

[0017] The buffer is easy to assemble and dismantle when it is needed to replace the hollow tube.

[0018] Conveniently the deforming member includes engaged therewith a locating member that acts on the deformable member interiorly of the tube; the tube includes two mutually divergent tapers; and the exterior cross section of the locating member tapers in two mutually divergent directions in a fashion complementary to the tapering of the tube, whereby the locating member is positively located relative to the deformable member.

[0019] It is also preferable that the locating member is compressively engaged with the deforming member.

[0020] Although it is possible to manufacture the hollow tube with a non-circular cross section, preferably the tube is longitudinally tapered and of circular cross section; the deforming member is of complementary external cross section; and the locating member includes a slit ring force transmittingly interconnecting the deforming member and the tube in the vicinity of the said tapers.

[0021] These features advantageously positively locate the slit ring relative to the plastically deformable, hollow tube; and also provide a shrink fit of the slit ring, while preventing rotation of the buffer components relative to one another.

[0022] In preferred embodiments of the invention the slit ring includes multiple slits, but the buffer of the invention will function even if the slit ring has only a single slit. Thus a possibility, within the scope of the invention, is to use a split ring instead of a slit ring. The primary function of the or each slit in the ring is to permit variation of the diameter of the ring. This in turn permits ready assembly of the ring into the (double) tapered tube.

[0023] The buffer start force (ie. the force needed to initiate plastic deformation of the deformable tube) is controlled by the geometry of the taper of the deformable hollow tube, and the thickness of the material of the tube in this region. The start force also includes a frictional force component that results from shrink fitting of the slit ring onto the deforming member and is determined by how tightly the slit ring is so shrink fitted. In any event, from a knowledge of the tapers and of the tightness of the shrink fitting the start force is predictable.

[0024] It is also desirable that the exterior of the deforming member tapers generally parallel to a taper of the interior of the tube; and the inner cross section of the slit ring tapers in a fashion complementary to the external taper of the deforming member.

[0025] This ensures that the slit ring is efficient in transferring impact loads from the deforming member to the deformable tube.

[0026] Also the aforesaid geometry advantageously ensures that the slit ring is compressed into the tapers of the deformable tube, and the deforming member, whereby the buffer accommodates buff forces.

[0027] Conveniently the deforming member includes a further hollow cylinder having an open end that is closed by a thrust plate having a part inserted into the open end and lying within the deformable tube, the thrust plate and the further, hollow cylinder being secured to one another by a tightenable fastener, tightening of the fastener causing expansion of the slit ring to increase the pressure of contact between the deforming member, the slit ring and the deformable tube.

[0028] The tightenability of the thrust plate into the end of the further, hollow cylinder gives rise to a known deformation start force. It is also ensures location of the slit ring relative to the plastically deformable hollow tube by virtue of positive engagement of the mutually divergent tapers of the slit ring defined hereinabove with the mutually divergent tapers formed in the interior wall of the plastically deformable, hollow tube.

[0029] In addition the shrink fitting of the slit ring onto the deforming member prevents relative rotation between the components when (as in the preferred embodiment) the hollow tube and deforming member are both of circular cross-section.

[0030] In one embodiment of the invention there is provided a buffer according to the broad aspect of the invention, wherein the deforming member includes engaged therewith a locating member that acts on the deformable member interiorly of the tube; wherein the internal taper of the tube narrows with increasing distance from the buffering element and the exterior of the locating member includes the said external taper; and wherein the buffer includes, at a location remote from the said external taper, at least two surfaces formed respectively on the deformable tube and the deforming member that are capable of transmitting forces acting between the deformable tube and the deforming member in a direction other than that in which the external taper of the deforming member transmits forces to the deformable tube.

[0031] This arrangement is simple and cheap to manufacture since there is no requirement for a slit ring. The locating member can if desired be solid or at least continuous.

[0032] Preferably the locating member abuts the deforming member, such that engagement of the external taper of the locating member with the internal taper of the tube urges the locating member against the deforming member. This advantageously retains the locating member relative to the deforming member. For additional stability however the buffer preferably also includes one or more dowels (or a functionally equivalent arrangement) linking the deforming member and the locating member together.

[0033] Although the action of the internal taper of the tube on the external taper of the locating member retains the latter relative to the deforming member, in embodiments of the invention that omit the mutually divergent tapers there is a need to retain the deforming member as a whole relative to the hollow tube. Preferably this need is met by the deforming member including, at a location remote from the locating member, a first shoulder that faces away from the internal taper of the deformable member; and the deforming member includes a further shoulder that faces towards the first said shoulder such that the transmission of forces between the said shoulders retains the deforming member within the hollow tube.

[0034] It is also preferable that the buffer includes a force transmitting member that force-transmittingly interconnects the first and further shoulders. This arrangement provides further advantages as set out herein.

[0035] In preferred embodiments of the invention the buffering element acts directly on the deforming member. However it is possible, within the scope of the invention, to devise an arrangement in which the buffering element acts on, and moves, the plastically deformable, hollow tube that engages a stationary deforming member.

[0036] Conveniently the deformable element includes extending therefrom a hollow housing, containing the buffering element, including co-operating constraint members for constraining movement of a moveable part of the buffer in the hollow housing.

[0037] This feature advantageously prevents rotation of the buffering element and other components connected thereto during an impact.

[0038] In one embodiment of the invention the housing is integral with the deforming member.

[0039] In another embodiment, that is of the aforesaid kind that omits the slit ring, the force transmitting member includes an annulus defining a pair of mutually spaced, annular abutment surfaces that respectively engage the first and further shoulders; and a hollow cylinder extends from the said annulus externally of the hollow tube to define the said hollow housing.

[0040] The arrangement advantageously combines the functions of a force transmitting member and a hollow guide housing in a single component.

[0041] In practical embodiments of the invention a moveable member of the buffer has secured thereto a buffer head, in order to provide a complete, two stage buffer.

[0042] More conveniently still, the constraint members include a key secured on the said moveable part by one or more fasteners; and

a keyway formed in the hollow housing and constraining movement of the key and hence the said moveable part, the said constraint members preventing detachment of the buffer head and the buffering element from one another.

[0043] Consequently the key that moves in the keyway also secures the buffer head relative to the buffering element in an advantageously compact arrangement.

[0044] The solid plate and hollow housing are held within the deformable member against the hollow cylinder by a retaining ring which is secured to the deformable member by tightenable fasteners. This locates the thrust plate relative to the plastically deformable hollow tube by virtue of positive engagement of the external taper of the thrust plate against the internal taper of the deformable member.

[0045] In all embodiments the buffering element may optionally be or include an hydraulic buffer capsule; a ring spring; or a polymeric or rubber buffer. The principles of the two stage buffer of the invention are effective regardless of the precise type of buffering element chosen.

[0046] There now follows a description of a preferred embodiment of the invention, by way of non-limiting example, with reference being made to the accompanying drawings in which:

Figure 1 is a vertically sectioned view of a two stage buffer according to the invention;
Figure 2 is a detail of the deformable tube and deforming member forming part of the Figure 1 arrangement, showing the condition in which the tightening bolts of the assembly are not tightened up;
Figure 3 is a force/stroke diagram of apparatus as shown in Figures 1 and 2; and
Figure 4 is a quarter sectioned view of an alternative embodiment of a two stage buffer.

[0047] Referring to Figures 1 and 2 there is shown a two stage buffer 10 according to the invention.

[0048] Buffer 10 includes a buffering element in the form of a *per se* known, hydraulic buffer capsule 12 the large diameter end 12a of which is in series, force transmitting contact with a deformable element 11 constituting the second stage of the buffer 10. The components of deformable element 11 are shown in detail in Figure 2. Capsule 12 forms a first stage (or primary element) of the buffer and deformable element 11 the second stage (or secondary element).

[0049] The arrangement between hydraulic capsule 12 and the components of deformable element 11 is such that impacts experienced by capsule 12 are transmissible to deformable element 11, by virtue of contact of end 12a with a component 24 (described in more detail below) of the deformable element 11, as best shown in Figure 2.

[0050] The deformable element 11 includes a plastically deformable, hollow cylindrical tube 14 having an internal taper 13.

[0051] Taper 13 reduces in diameter with increased distance from capsule 12.

[0052] A deforming member in the form of a further, hollow tube 15, of generally complementary external cross section to the interior of tube 14, is inserted into the end of hollow tube 14 nearest to capsule 12.

[0053] Deforming member 15 has an external taper 20 located at its end remote from capsule 12.

[0054] The angle and direction of taper 20 are substantially the same as the angle and direction of taper 13, but the dimensions of taper 20 are such as to permit member 15 to lie within taper 13.

[0055] Nonetheless the taper of the deforming member 15 is capable of transmitting force to the taper 13 of the deformable cylinder 14 by virtue of the presence of a slit ring 16 interposed between taper 20 and taper 13. Thus in practice the slit ring may be regarded as the operative part of the deforming member; with the tube 15 (and thrust plate 18 described below) acting to support the slit ring 15.

[0056] Slit ring 16 is in the embodiment shown an annulus having a cross section, described in more detail below, that occupies the space between tapers 13 and 20. The slit ring includes at least one slit, as indicated at 16a, whereby its diameter is adjustable. In other words slit ring 16 is elastically deformable to permit assembly of the buffer 10, by compression of ring 16 to permit it to pass into tube 14.

[0057] In practice slit ring 16 may include a plurality of slits preferably spaced at equal intervals about the circumference of annulus defined by slit ring 16. In such embodiments the slit ring may be constituted by an annulus of discrete ring segments.

[0058] In addition to taper 13, that diminishes in diameter with increasing distance from capsule 12, tube 14 also includes, extending from taper 13 towards capsule 12 from taper 13, a second taper 19.

[0059] The exterior cross section of slit ring 16 similarly includes mutually divergent, contiguous tapers 21,22 that are complementary in angle and direction respectively to tapers 13 and 19 of plastically deformable tube 14.

[0060] The inner circumference of the annulus defined by slit ring 16 includes a further taper 23 of generally complementary shape to the taper 20 defined on the exterior of the free end of deforming member 15.

[0061] As a result of the presence of tapers 13, 19 and 20, and the shape of the cross section of slit ring 16 as described, slit ring 16 is capable of transmitting forces from deforming member 15 to the taper 19 of deformable tube 14. This prevents the member 15 from being withdrawn from the tube 14. Thus the slit ring 16 is positively located, relative to tube 14, in both the buff and draft directions.

[0062] The taper 19 serves in particular to support the buffer head under the aforementioned side loading.

[0063] The section of tube 14 between the taper 19 and the mouth of the tube adjacent the buffer/buffer head is a guiding zone. Since it is essential to use ductile material for the deforming tube, this section has a thick end wall to compensate for the low yield point of the material and provide enough stiffness as is necessary for the guiding effect. In a pre-used condition the section of the tube 14 above the taper 19 and 13 is not cold hardened. When the deforming element actuates and starts to stroke the deformed area is work hardened. The work hardening assists the guiding action. However the element has to be capable of withstanding significant side load in a stage where the deforming element has not been actuated, hence the thickened wall portion.

[0064] Describing now the deforming member 15 in more detail, the free end thereof adjacent slit ring 16 is formed as an open-ended, hollow cylinder that is closed by a thrust plate 18 formed as a parallel sided, hollow cylinder having a peripheral flange 18a at one end thereof, such that flange 18a overlies the wall of deforming member 15 at the free end thereof.

[0065] At a location remote from taper 13, and adjacent the end 12a of capsule 12, deforming member 15 is formed as a solid plate spanning the hollow cylindrical interior of deforming plate 24.

[0066] Thrust plate 18 is perforated in at least two locations as shown by throughgoing apertures 26,27 that extend parallel to the longitudinal axis of deforming member 15.

[0067] Plate 24 is perforated by further, threaded apertures 28,29 that are aligned with the respective apertures 26,27. A plurality of screws 17 are inserted through the apertures 26,27 and threadedly engaged in apertures 28,29 to provide a retaining force for retaining the thrust plate 18 inserted into the open end of the hollow cylindrical portion of deforming member 15. In the preferred embodiment there are twelve screws 17 although the precise number of screws may be varied to suit design requirements.

[0068] The screws 17 constitute a tightenable fastener for securing the thrust plate and the hollow cylinder forming part of deforming member 15 together.

[0069] Figure 2 shows the condition in which the screws 17 are not fully tightened. In this condition the free end 20a of deforming member 15 (adjacent taper 20) is spaced from flange 18a. On tightening of the screws 17 the free end 20a and the flange 18a are drawn closer together in the direction of the longitudinal axis of the buffer 10, with the result that the slit ring 16 expands in the space between the tapers 20 and 13. As a result the pressure of contact between taper 20, taper 13 and slit ring 16 increases such that the slit ring is shrink fitted on to the exterior of tube 15.

[0070] In this way the tightening of the screws 17 introduces longitudinal forces that are similar in magnitude to the forces arising during deformation of the cylinder in use. This advantageously provides a controlled start force when the device of the invention is used to absorb an impact.

[0071] This arrangement conveniently and simply permits pre-setting of the start force of the secondary element of the buffer 10, whereby the secondary element 11 only operates when the impact force experienced by the buffer exceeds a predetermined value. The start force is determined by both the force necessary to initiate plastic deformation of tube 14; and friction forces resulting from the shrink fitting of slit ring 16.

[0072] Consequently the disadvantage, evident in many of the prior art, two stage buffers, of the start force of the secondary element being unknown, does not arise in the two stage buffer of the invention. Thus the shear members of FR-A-2 789 358 are not needed in the buffer of the invention.

[0073] The solid plate 24 performs a secondary function, in acting as a reaction member for the large diameter end 12a of hydraulic buffer capsule 12, that rests, and consequently acts, directly thereon.

[0074] In another embodiment (not shown in the drawings) the capsule 12 could lie the other way round, ie. so that its small diameter end 12b engages the plate 24.

[0075] The hollow cylinder defining deforming member 15 extends beyond solid plate 24 as a hollow, cylindrical housing 32 (Figure 1) that encircles capsule 12.

[0076] Housing 32 includes co-operating constraint members for constraining movement of a moveable part of the buffer 10 within the hollow housing 32, in the form of a slot 33 extending longitudinally along part of the length of housing 32 to define a keyway; and a key 34 that is slidably constrained to move longitudinally in slot 33.

[0077] Key 34 is secured by further screws 36 to the cylindrical parts of a buffer head 37 that may be of *per se* known design.

[0078] In a conventional manner, the portion 37a of buffer head 37 that terminates the interior of the hollow, cylindrical part thereof is in force-transmitting engagement with the free end of the piston 12b of capsule 12.

[0079] It follows that in use of the buffer 10 impact forces acting on buffer head 37 are transmitted initially to piston 12b, with the result that capsule 12 compresses.

[0080] The effect of key 34, being secured to buffer head 37, sliding in slot 33 is to prevent rotation of buffer head 37 relative to the remainder of the buffer 10 during impact; and to prevent buffer head 37 from becoming detached from the remainder of the components. This in turn ensures that capsule 12 is retained in place within the hollow part of head 37.

[0081] In an alternative embodiment of the invention shown in Figure 4, the deforming member 15 includes a hollow cylinder that is open at either end and is received within the hollow interior of tube 14. The open end 15a of deforming member 15 that is remote from capsule 12 is closed by a locating member 51 formed as a parallel sided, solid cylinder having at its free end an external taper 52 which decreases in diameter in the direction away from buffer capsule 12. Tube 14 includes an internal taper 53 that is of complementary shape to external taper 52. Engagement of the tapers 52, 53 tends to retain locating member 51 relative to deforming member 15. Additionally the locating member 51 and deforming member 15 are secured together by a plurality of dowels 43 inserted into mutually aligned bores 54 formed respectively in end 15a of deforming member 15 and the adjacent, rear face of locating member 51. The bores 54 extend parallel to the longitudinal axis of deforming member 15.

[0082] The engagement of the respective tapers 52, 53 constrains movement of locating member 51 and deforming member 15 further into tube 14, until the buffer 10 experiences a sufficiently large force as to initiate movement of the deforming member 15.

[0083] On the other hand in the Figure 4 embodiment there is no equivalent of the reverse taper 19, of the Figure 1, 2 embodiment, that prevents withdrawal of the deforming member from the tube 14.

[0084] This function instead arises in the Figure 4 embodiment by virtue of two mutually juxtaposed surfaces 56, 57 that coact, via a force transmitting member 58, to transmit forces acting between the tube 14 and the deforming member 15 in a direction other than that in which the tapers 52, 53 transmit forces, and that tend to cause withdrawal of the deforming member 15 from the tube 14.

[0085] The surface 56 is defined in the end of member 15 remote from taper 52, as an annular shoulder that results from the presence of a reduced diameter end portion 15b of member 15. As a result, surface 56 faces capsule 12.

[0086] Juxtaposed surface 57 is defined by a radially inwardly extending flange ring 59 that is secured to the open end of tube 14 (in which member 15 is received) by a series of fasteners such as the screws 61 shown threadedly received in associated bores; or by equivalent means.

[0087] A force transmitting member in the form of hollow cylinder 58 interconnects the surfaces 56, 57 so as to transmit the aforesaid forces therebetween.

[0088] Cylinder 58 has a free end that engages surface 56; and an upstanding shoulder 58a that engages surface 57.

[0089] Radially inwardly of its engagement with surface 57 the shoulder 58a terminates in a cylindrical wall of lesser diameter than cylinder 58. This wall protrudes externally of the tube 14 to define a housing 32 that is functionally similar to housing 32 visible in Figure 1.

[0090] The diameters of the various cylindrical components in the vicinity of surfaces 56, 57 and flange ring 59 are such as to cause retention of cylinder 58 and deforming member 15 within tube 14 while permitting movement of deforming member 15 along tube 14 when required.

[0091] At a location remote from taper 52, and adjacent to the end 12a of capsule 12, deforming member 15 is closed by a solid plate 24. The solid plate 24 acts as a reaction member for the large diameter end 12a of hydraulic buffer capsule 12 that rests, and consequently acts, directly thereon.

[0092] In an alternative arrangement (not shown in the drawings) the capsule 12 lies the other way round, so that its small diameter end 12b engages the plate 24.

[0093] The flange ring 59 constitutes a tightenable fastener for securing the hollow cylinder 58, solid plate 24, and deforming member 15 within tube 24. This arrangement prevents the deforming member 15 from being withdrawn from the tube 14. Thus the locating member 51 is positively located relative to tube 14 in both the buff and draft directions.

[0094] Housing 32 encircles capsule 12. Housing 32 extends in a direction parallel to deformable member 15 towards the buffer head 37.

[0095] If in use of either embodiment of the invention an impact force the buffer experiences is less than a predetermined threshold value, its effect will simply be to compress capsule 12 in a *per se* known manner, with buffer head 37 sliding further into housing 32. Typically capsule 12 includes an hydraulic circuit that damps the impact energy according to a known force - stroke curve.

[0096] The hydraulic capsule 12 also typically contains an energy converter in the form of a volume of compressible gas, that restores the capsule 12 to its pre-impact length after occurrence of an impact.

[0097] The resistive force of the hydraulic buffer capsule 12 is dependant upon the internal static forces controlled by the gas inflation of the buffer plus the dynamic element of oil forced through an orifice.

[0098] At high impact speeds the force rises above the plastic deformation threshold of the deformable member 14. In this situation the deformable member 14 moves at such a velocity that the effective velocity of the plunger relative to the cylinder would generate eg. a 1200kN load across the hydraulic buffer. It is thus likely that the hydraulic and deforming stages of the buffer would operate concurrently.

[0099] By virtue of the rigid construction of deforming member 15, impact forces experienced by solid plate 24 are transmitted via taper 20 and slit ring 16 (in the Figure 1 embodiment); or member 51 (in the Figure 4 embodiment) to taper 13 or taper 53 (as appropriate) of deformable tube 14.

[0100] If the impact force is sufficient to exceed the above-mentioned start force of the deformable stage of the buffer 10, deforming member 15 travels along deformable tube 14 effectively ironing the walls thereof in the region to the right of taper 13 as shown in Figures 1 and 2, with the result that the taper 13 "moves" along the length of the tube 14.

[0101] Such deformation of the tube absorbs the impact energy in a consistent and predictable manner, as is evident from Figure 3 that plots the dynamic impact force against the stroke of the deforming member 15 in the deformable tube 14 for the Figure 1 embodiment.

[0102] In practice the design of deformable element 11 gives rise to a peak force component 41 that is greater than the start force 39 necessary to initiate plastic deformation at the start of the stroke.

[0103] Consequently the buffer 10 of the invention includes an inherent assurance that plastic deformation of the tube 14 does not commence unless the impact force exceeds a predetermined threshold value that in the embodiment plotted in Figure 3 is approximately 1400 kN.

[0104] Once plastic deformation of the tube 14 commences, as shown by region 42 of Figure 3, the constant force characteristic of the secondary element 11 of the buffer is substantially a straight, horizontal line whereby the area under the plotted line of Figure 3 is maximised. It follows from this that energy absorption in the secondary element 11 also is a maximum.

[0105] Figure 3 plots a dynamic force component. Similar results can of course be plotted for a static force. In a preferred embodiment of the invention the static force is typically 5% higher than the dynamic (impact) force.

[0106] Figure 3 shows the force/stroke characteristic of a buffer 10 according to the invention in which the constant force (represented by portion 42 of the plot) is designed to be 1200kN. Of course through judicious choice of the dimensions and materials of the components constituting the secondary element 11, other nominal constant force buffers can be created.

[0107] As noted herein, the buffer of the invention is highly effective at buffering side loads applied obliquely to the buffer head at angles of up to 8° to the longitudinal axis of the buffer.

[0108] The following table shows the results of trials involving the application of side loads to a buffer 10 whose nominal constant force of the secondary element 11 is 1200kN.

Direction of load	Constant Force (CF) (42)	Peak Force (PF) (41)	Start Force (SF) (39)
	kN	kN	kN
0°	1200	Maximum 1600	Minimum 1200
4°	1320	Maximum 1600	Minimum 1200

(continued)

Direction of load	Constant Force (CF) (42)	Peak Force (PF) (41)	Start Force (SF) (39)
	kN	kN	kN
8°	1380	Maximum 1600	Minimum 1200

[0109] Although the embodiment described herein includes the hydraulic capsule 12 shown, the primary buffering element may of course be replaced by other energy absorbing apparatuses including, but not limited to, ring springs.

[0110] In the embodiment shown in Figures 1 and 2 the choices of material of the slit ring 16 and deformable tube 14 assure the correct constant force 42. In the preferred embodiments the slit ring 16 is manufactured from hardened steel BS970 708 M40t-condition (min hardness 266 VH), in order to ensure that it does not deform as it deforms tube 14. Of course slit ring 16 could be manufactured from other materials of known hardness.

[0111] Tube 14 is manufactured from annealed, cold drawn steel tube.

[0112] Deforming member 15 can be manufactured from eg. a general construction steel (such as BSEN10025: 1993:S355J2G3) that is normalised to permit safe plastic deformation.

[0113] The choice of alloys for slit ring 16 and tube 14 advantageously minimises the risk of welding of the slit ring 16 to tube 14 during operation of the secondary element 11, thereby assisting to provide the substantially flat plot in portion 42 of Figure 3.

[0114] A further advantage of the apparatus of Figures 1 and 2 is that the slit ring 16 causes localised brinelling of tube 14 during operation to absorb impact energy. Since the direction of movement of slit ring 16 in tube 14 is parallel to the longitudinal axis of tube 14, such brinelling effectively keys slit ring 16 in the tube 14 and further prevents rotation of deforming member 15 relative to tube 14 during working of the secondary element 11.

[0115] Another advantage arises from the presence of reverse taper 19, that form-locks slit ring 16 and deforming member 15 (by virtue of reaction of flange 18a against slit ring 16) relative to tube 14.

[0116] Since the force characteristic of the buffer 10 is accurately controllable (as evidenced by the plot constituting Figure 3), the buffer operates so as not to interfere with anti-climb apparatus that may be secured to eg a railway vehicle.

[0117] Furthermore as noted herein, the length of tube 14 may be selected at the option of the buffer designer. Thus for example a unit intended for installation on a locomotive headstock might have a maximum stroke (ie effective length of tube 14) of 600 mm; whereas a railway carriage might have a maximum stroke of 150 mm. The choice of the length of tube 14 also permits manufacture of a device having a minimal risk of interfering with anti-climb apparatus.

[0118] In the Figure 4 embodiment, two keyways (not visible in the drawings) lie directly opposite one another on the outer surface of locating member 51. When impact occurs the keyways key themselves onto the deformable member. This effect further prevents rotation of deforming member 15 relative to tube 14 during working of the secondary element 11.

Claims

1. A two stage buffer comprising a buffering element and a deformable element connected in series whereby forces are transmissible from the buffering element to the deformable element, **characterised in that** the deformable element includes:

   a plastically deformable, hollow tube having an internal taper; and
   a deforming member of generally complementary external cross section to the interior of the tube and having an external taper, the deforming member being inserted into the tube such that the taper of the deforming member is capable of transmitting forces to the internal taper of the cylinder and *vice versa*; and the buffering element being in force transmitting engagement with the deformable element,

   whereby forces experienced by the buffer that are insufficient to cause plastic deformation of the tube are buffered by the buffering element; and greater forces are transmitted between the taper of the deforming member to the taper of the tube to cause plastic deformation thereof.

2. A buffer according to Claim 2 wherein the deforming member includes engaged therewith a locating member that acts on the deformable member interiorly of the tube; wherein the tube includes two mutually divergent tapers; and wherein the exterior cross section of the locating member tapers in two mutually divergent directions in a fashion complementary to the tapering of the tube, whereby the locating member is positively located relative to

the deformable member.

3. A buffer according to Claim 2 wherein the locating member is compressively engaged with the deforming member.

4. A buffer according to Claim 1 wherein the tube is longitudinally tapered and of circular cross section; the deforming member is of complementary external cross section; and the locating member includes a slit ring force transmittingly interconnecting the deforming member and the tube in the vicinity of the said tapers.

5. A buffer according to any of Claims 2 to 4 wherein the exterior of the deforming member tapers generally parallel to a taper of the interior of the tube; and wherein the inner cross section of the locating member tapers in a fashion complementary to the external taper of the deforming member.

6. A buffer according to Claim 3 or any preceding claim dependent therefrom wherein the deforming member includes a further, hollow cylinder having an open end that is closed by a thrust plate having a part inserted into the open end and lying within the deformable tube, the thrust plate and the further, hollow cylinder being secured to one another by a fastener.

7. A buffer according to Claim 1 wherein the deforming member includes engaged therewith a locating member that acts on the deformable member interiorly of the tube; wherein the internal taper of the tube narrows with increasing distance from the buffering element and the exterior of the locating member includes the said external taper; and wherein the buffer includes, at a location remote from the said external taper, at least two surfaces formed respectively on the deformable tube and the deforming member that are capable of transmitting forces acting between the deformable tube and the deforming member in a direction other than that in which the external taper of the deforming member transmits forces to the deformable tube.

8. A buffer according to Claim 7 wherein the locating member abuts the deforming member, such that engagement of the external taper of the locating member with the internal taper of the tube urges the locating member against the deforming member.

9. A buffer according to Claim 8 including one or more dowels linking the deforming member and the locating member together.

10. A buffer according to any of Claims 7 to 9 wherein the deforming member includes, at a location remote from the locating member, a first shoulder that faces away from the internal taper of the deformable member; and the deforming member includes a further shoulder that faces towards the first said shoulder such that the transmission of forces between the said shoulders retains the deforming member within the hollow tube.

11. A buffer according to Claim 10 including a force transmitting member that force-transmittingly interconnects the first and further shoulders.

12. A buffer according to any of Claims 7 to 11 including an annular flange member that is secured to the open end of the tube to define the said further shoulder.

13. A buffer according to any preceding claim wherein the buffering element acts directly on the deforming member.

14. A buffer according to any preceding claim wherein the deformable element includes extending therefrom a hollow housing containing the buffering element, and including co-operating constraint members for constraining movement of a moveable part of the buffer in the hollow housing.

15. A buffer according to Claim 13 wherein the housing is integral with the deforming member.

16. A buffer according to Claim 14 when dependent from Claim 11 wherein the force transmitting member includes an annulus defining a pair of mutually spaced, annular abutment surfaces that respectively engage the first and further shoulders; and wherein a hollow cylinder extends from the said annulus externally of the hollow tube to define the said hollow housing.

17. A buffer according to any preceding claim wherein a moveable member of the buffer has secured thereto a buffer head.

18. A buffer according to Claim 17 when dependent from Claim 14, wherein the constraint members include a key secured on the said moveable part by one or more fasteners; and
 a keyway formed in the hollow housing and constraining movement of the key and hence the said moveable part, the said constraint members preventing detachment of the buffer head and the buffering element from one another.

19. A buffer according to any preceding claim wherein the deformable, hollow tube includes a thickened region that work hardens during deformation of the said tube.

20. A buffer according to any preceding claim, wherein the buffering element is or includes an hydraulic buffer capsule.

21. A buffer according to any of Claims 1 to 19 wherein the buffering element is or includes a ring spring.

22. A buffer according to any of Claims 1 to 19 wherein the buffering element is or includes a polymer or rubber buffer element.

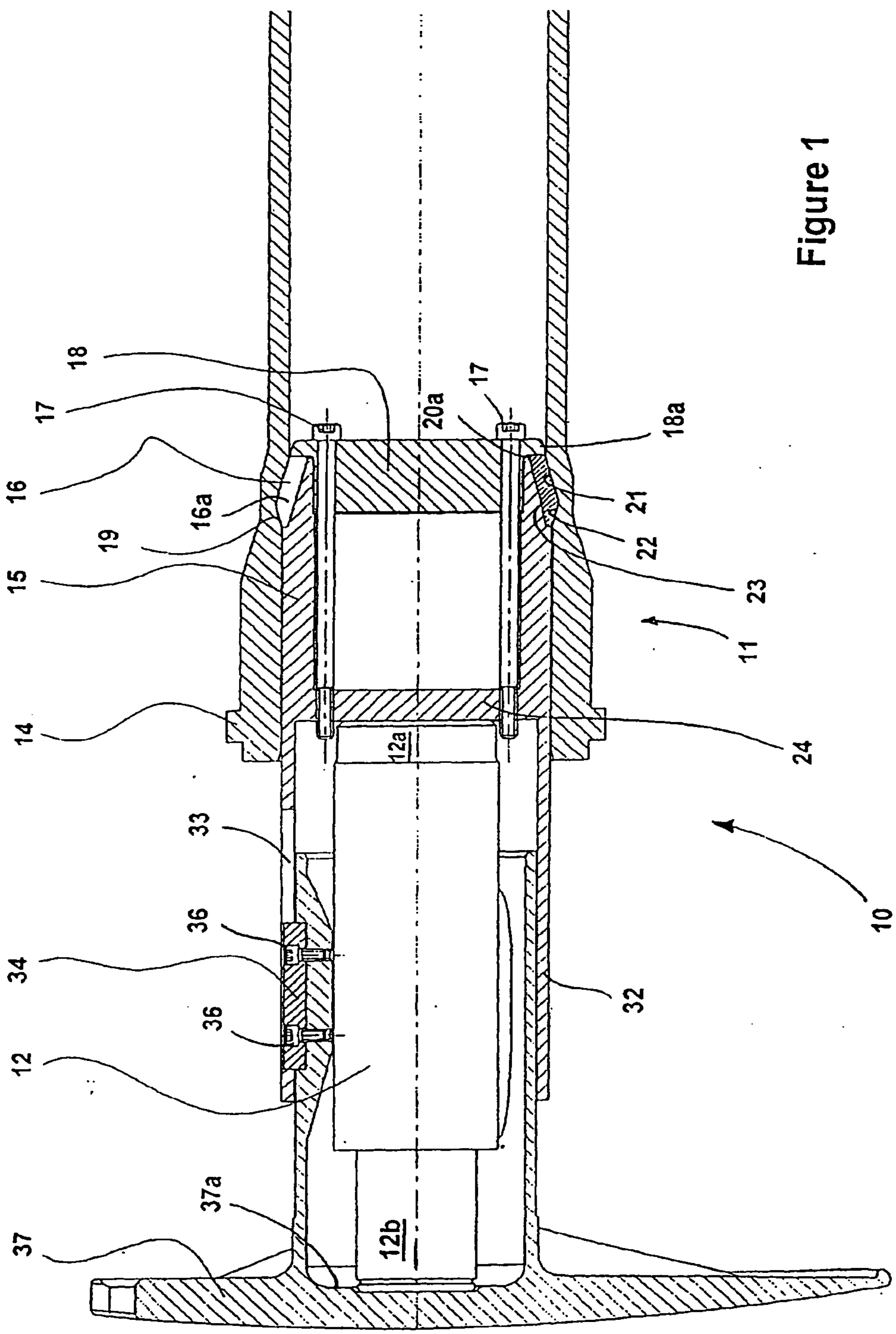
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Figure 1

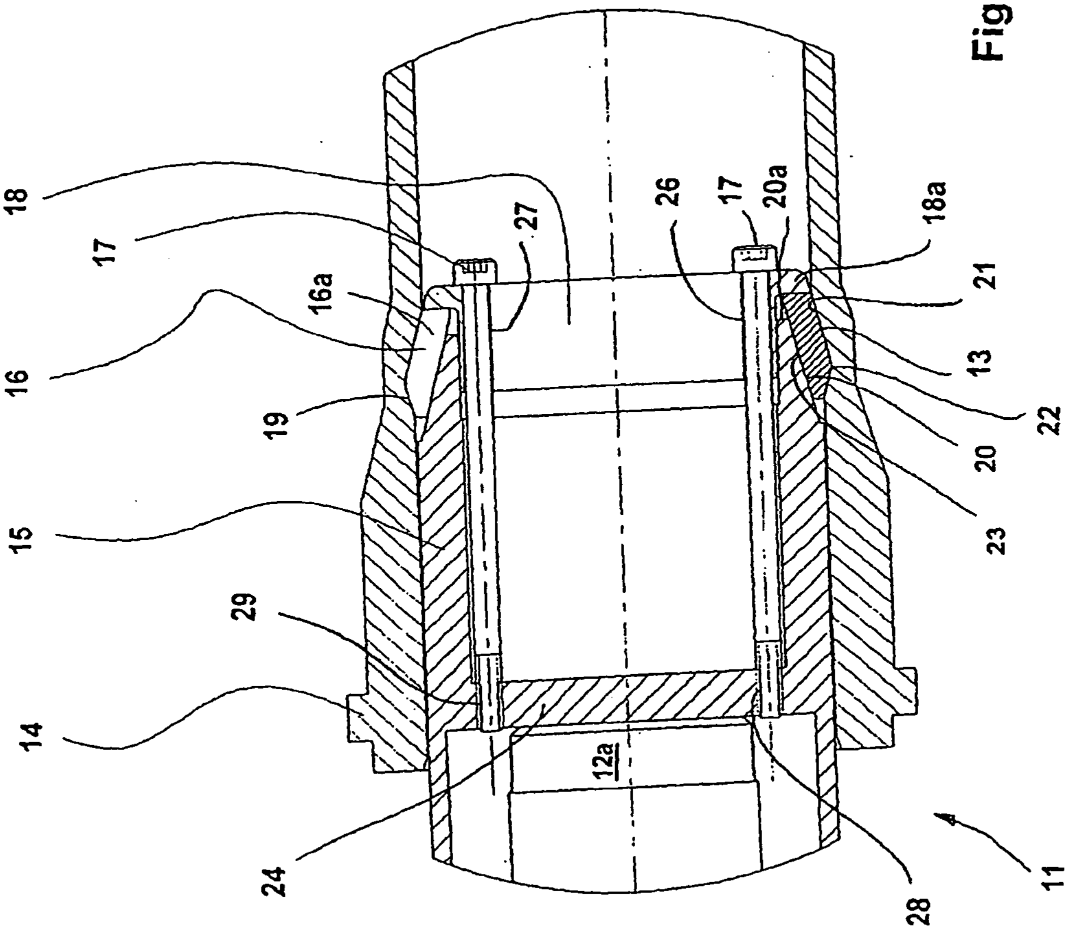

Figure 2

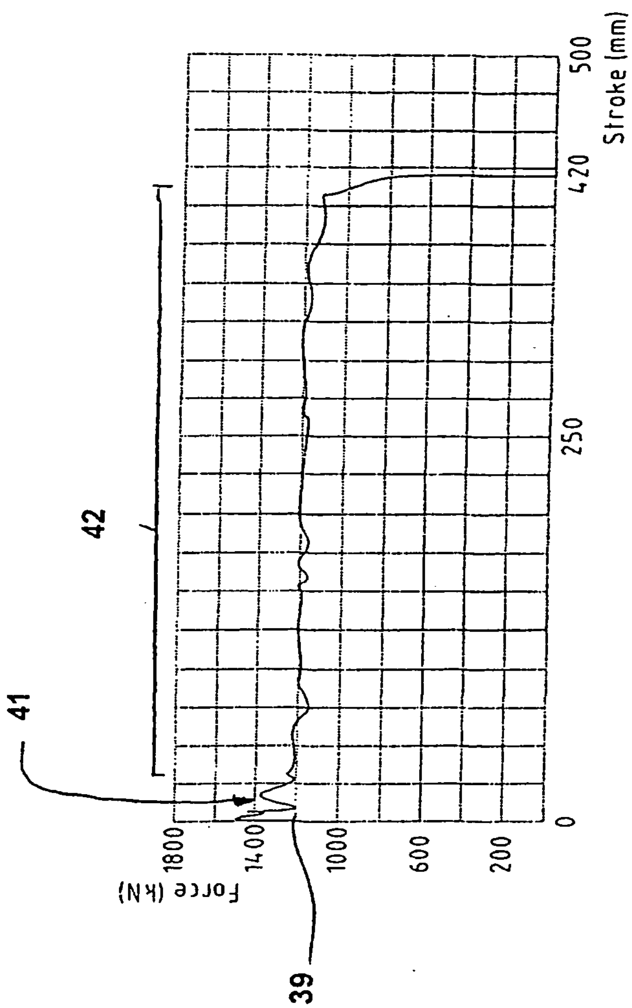

Figure 3

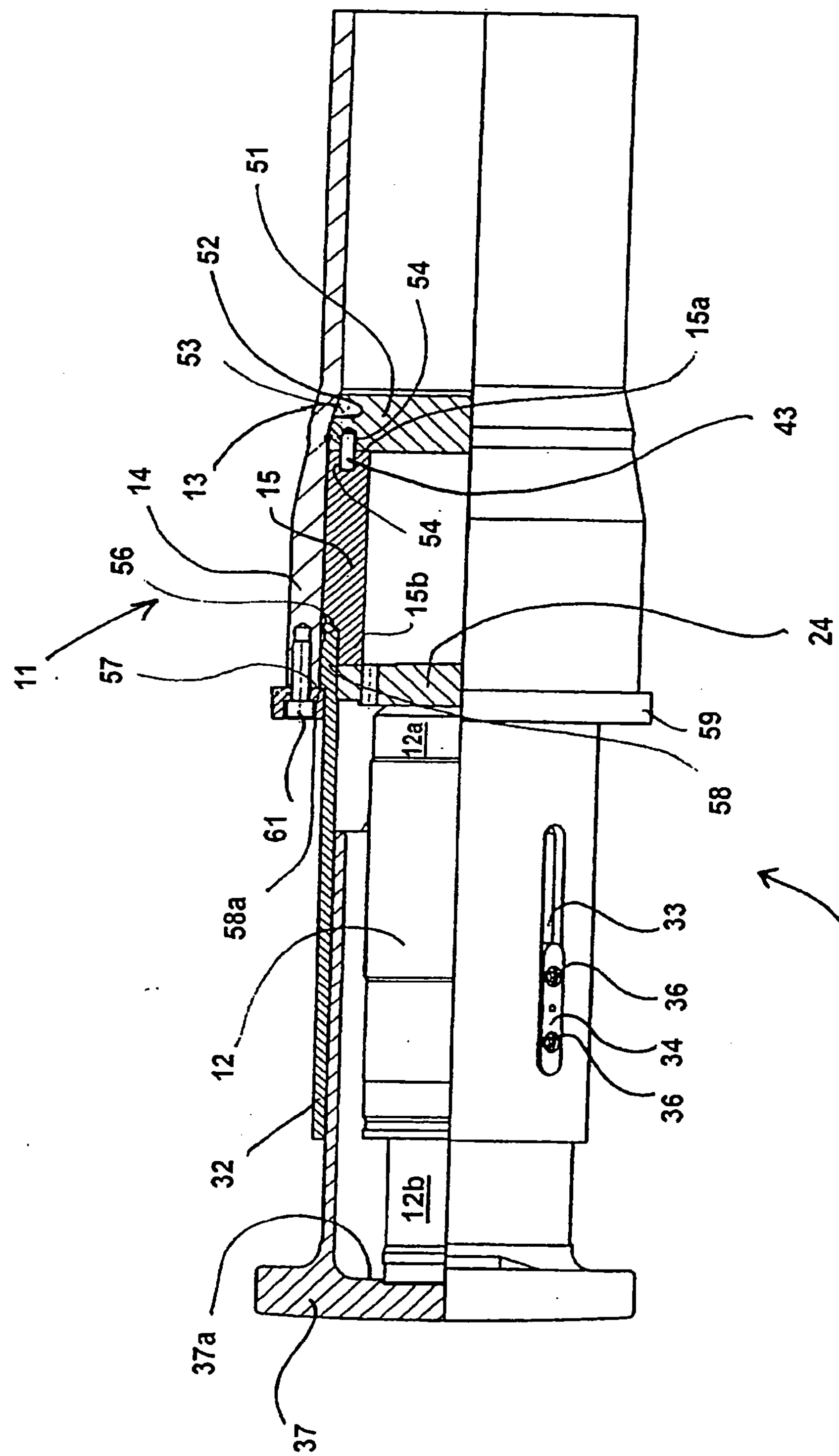
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Figure 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 2068

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	25 July 2002	Ferranti, M

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X : particularly relevant if taken alone
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